CHAPTER 9

MAGNETIC TAPE STORAGE

INTRODUCTION

Computers use three types of storage devices to store and access data. These are main memory storage, secondary memory storage, and tertiary storage. Main memory is the memory in the computer itself. It can be semiconductor RAM, magnetic core memory, or thin film memory. Secondary memory storage is memory used to store data that is not immediately required by the computer. The most common secondary memory is some type of magnetic disk. Tertiary memory storage is used to store large amounts of data that are not required by the computer on a regular basis. Magnetic tape can be used as secondary storage, but it is generally used as a tertiary storage media.

After completing this chapter you will be able to:

- **Describe the physical properties of magnetic tape**
- **Describe the proper procedures for handling, storing, and packaging magnetic tape**
- **Describe magnetic tape failures due to normal wear and tear, accidental damage, environmental damage, and winding errors**
- **Describe the function and operation of the magnetic tape read, write, and erase heads**
- **Describe the different methods of encoding data on magnetic tape**
- **State the purpose of the major functional areas of a magnetic tape unit**
- **Describe the operations performed by a magnetic tape unit**
- **Describe the operation of a magnetic tape transport**

Magnetic tape units may be categorized by the form of media they are designed to use: open-reel, cartridge, and cassette. The standard tape units use open reels. Cartridge or cassette units use cartridge tapes and cassette tapes, respectively.

The units most commonly used in the Navy are industry standard open-reel tape units and cartridge tape units.

TOPIC 1—MAGNETIC TAPE

Magnetic tape is one form of magnetic storage media. It consists of a thin film of magnetic oxide material bonded to a polyester-based strip. Magnetic tape offers several useful features:

- Magnetic tape can be used to store large amounts of data in a variety of convenient package sizes (reels, cartridges, or cassettes)
- Magnetic tapes are easily interchangeable between similar units of different systems

- Magnetic tape is less prone to damage than other forms of magnetic storage media

PHYSICAL PROPERTIES OF MAGNETIC TAPE

Magnetic tape comes in a variety of widths and lengths. It maybe contained in one of three categories of storage media: industry standard open reels, cartridges, or cassettes. Figure 9-1 shows the different categories of magnetic tape media.

MAGNETIC TAPE CONSTRUCTION

Three basic materials are used to make magnetic tape. They are:

- The base material
- A coating of magnetic oxide particles
- A glue that binds the oxide particles to the base material

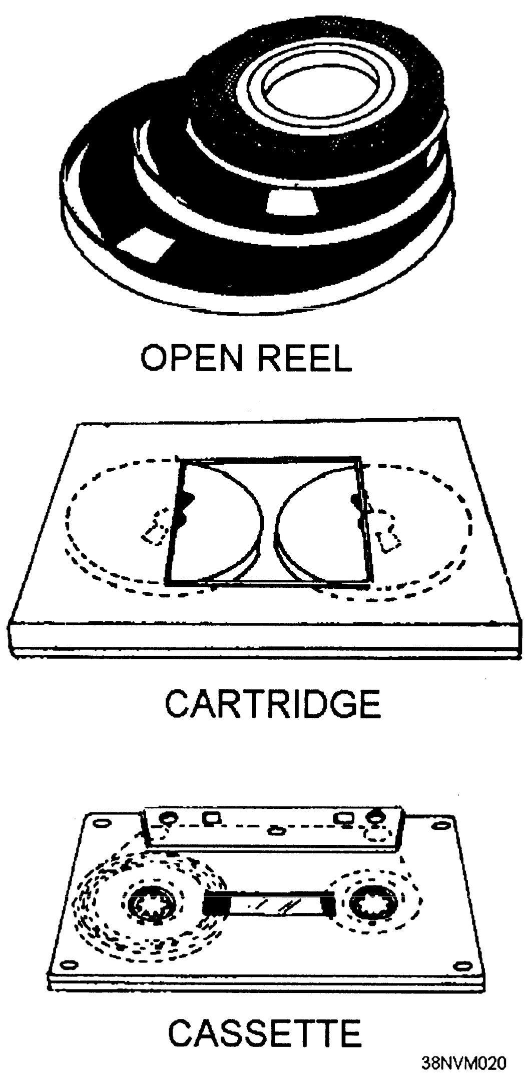

Figure 9-1.—Magnetic tape reels, cartridges, and cassettes.

Figure 9-2 illustrates the basic construction of a magnetic tape.

Base Material

The base material for magnetic tape is made of either plastic or metal. Plastic tape is more common because it is very flexible, resists mildew and fungus, and is very stable at high temperatures and humidity.

Oxide Coating

Oxide particles that can be easily magnetized (ferrous) are coated onto the base material. The most common oxide materials are gamma ferric oxide and chromium dioxide. It is very important that the oxide particles are uniform in size and shape. If they are not, the tape's surface will be abrasive and might damage the tape unit's head.

Glue

The glue used to bond the oxide to the base is usually an organic resin. It must be strong enough to hold the oxide in place, yet flexible enough not to peel or crack.

MAGNETIC TAPE HANDLING PROCEDURES

Magnetic tape handling procedures include the storage, handling, maintenance, and control of tapes.

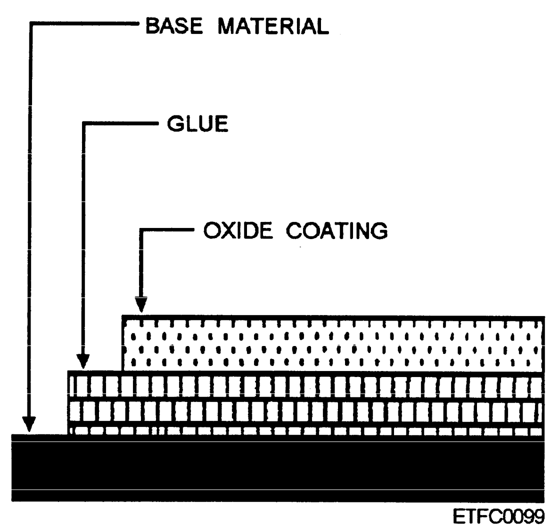

Figure 9-2.—Magnetic tape construction.

Tape Storage and Handling

To extend and enhance the reliability and performance of magnetic tape reels, cartridges, cassettes, and their respective units, you should adhere to the following rules:

- Store tape reels, cartridges, and cassettes in dustproof containers whenever they are not in use.

- When the reel, cartridge, or cassette is mounted on or in the unit, keep its storage container closed and free from exposure to dust and dirt. Periodically inspect containers for dust and dirt contamination.

- Store reels, cartridges, and cassettes in an electromagnetic shielded cabinet elevated from the floor and free of contaminants. See figure 9-3 for an example.

- Do not use the top of equipment as a working area. Placing reels, cartridges, or cassettes on the top of electronic equipment may expose them to excessive heat, electromagnetic radiation, or contaminants from unit blowers.

- Use adhesive stickers that can be removed without leaving a residue to identify the contents of reels, cartridges, and cassettes.

- Do not erase labels on adhesive stickers with a rubber eraser; the particles from the eraser may come in contact with the tape.

Magnetic tape is sensitive to environmental changes in temperature and humidity. To prevent problems caused by changes in environment, do:

- Store reels, cartridges, and cassettes in the room where they are used; storing tapes near the unit reduces handling and the effects of variations in environmental conditions.

- Maintain constant temperature and humidity ranges (65° to 85° Fahrenheit or 18° to 32° Centigrade with 40 to 60 percent humidity).

- Condition new tapes, or tapes from other systems, to your computer room by keeping them in your computer room for a 24-hour period before use; also condition tapes removed from your computer room upon their return, and before their reuse.

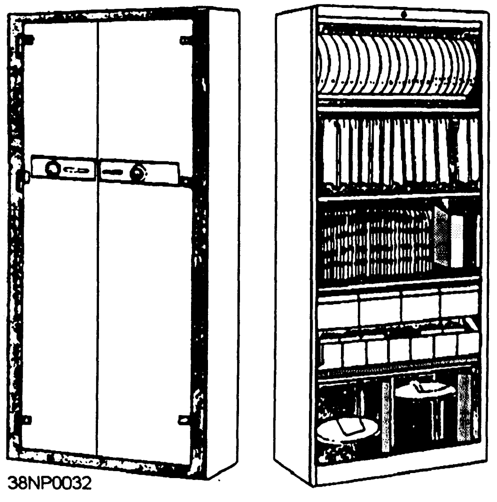

Figure 9-3.—A magnetic media storage container.

Human handling of magnetic tapes can itself cause tape and unit problems. Magnetic recording surfaces are delicate and sensitive to dust, airborne contaminants, and the oils, acids, and other contaminants contained on human skin. **DO NOT** handle the metallic oxide surface of magnetic recording media, in particular the usable recording surface between beginning-of-tape (BOT) marker and end-of-tape (EOT) marker.

The contaminants contained on human skin are harmful to both the oxide coating of magnetic tape and the precision mechanics of the unit using the tape. All surfaces of the unit should be cleaned thoroughly following handling. In addition, clean magnetic tape units periodically, as specified in the unit's technical manual and/or Planned Maintenance System (PMS) Maintenance Index Pages (MIPs) and Maintenance Requirement Cards (MRCs).

Tape Maintenance

Magnetic tapes, particularly tapes on open reels, require several maintenance actions. These maintenance actions are cleaning, certifying, degaussing, stripping, and splicing.

CLEANING.—DO not clean magnetic tape by hand. A special machine is used to clean tape. The **tape cleaner** performs two functions:

- It shaves the oxide side of the tape with a series of razors to remove any loose oxide and embedded particles

- It then wipes down both sides of the tape with a cleaning solution to remove any remaining oxide particles or contaminants

Tape cleaners do not alter the flux patterns stored on a tape; however, cleaning tapes on which information is stored is **not recommended,** Tape cleaners will reduce the static charge buildup on open-reel tapes and will help eliminate **tape cling.** All tapes should be cleaned and certified annually.

CERTIFICATION.— Tape certification requires the use of a tape certifier machine. A **tape certifier** performs digital and analog evaluations of a tape against a calibrated standard. The objective of the certifier is to exercise the tape far in excess of the operational requirements of its tape unit.

The tape certifier checks the ability of the tape to record high-density data, to retain magnetic flux patterns, and to be demagnetized. The certifier performs tape cleaner functions before testing the tape. It also leaves the tape completely erased after testing. Tapes that are certified error free to a particular density will, in all probability give months of error-free performance. Tapes that cannot be certified should be destroyed.

DEGAUSSING.— A **degaussing machine** is in effect a big tape eraser. The machine applies an ac-induced electromagnetic field of varying strengths to the tape. The field completely nullifies all the magnetic flux patterns stored on the tape.

Degaussing provides for a complete erasure of all information stored on a tape. It maybe used to remove classified data from tape as specified in the *ADP Security Manual,* DOD 5200.28-M, sections VII and VIII.

STRIPPING.— Magnetic tape tends to show the greatest wear on the portions of the tape immediately following the BOT marker. Seldom is an entire tape reel used to store data; only a third of the tape or less is used for storing data in most applications.

Excessively worn or damaged areas of tape maybe stripped (cut away) from the reel, and a new BOT marker installed on the tape. Stripping is a useful tool for those installations that do not have tape cleaners or certifiers available.

NOTE: Do not strip open reels down to less than 500 feet of tape, since the remaining usable storage area is limited. Standard reels containing less than 500 feet of tape should be discarded.

SPLICING.— Taping together two broken ends of tape to make one tape is called **splicing.** Splicing is **not recommended** for the following reasons:

- Tape splices are generally the weakest point on the tape and could separate during operation
- Read and write operations may not perform properly in the area of a splice; tape splices may appear as bad spots on tape
- Splicing a broken tape usually does not save the data stored on the tape

Open-reel tapes that break may be stripped to the break and have a new BOT marker installed. This way the remaining tape on the reel maybe used effectively. Discard cartridges or cassettes that have tape breaks.

Tape Control

Of major importance to you as a technician is the amount of attention paid to the control of magnetic tapes. Nothing is more embarrassing or potentially destructive than the loss of the last copy of a maintenance program, operational program, or data file. The least problem such a loss could cause would be the time lost in regenerating or acquiring a new copy of the program or data. The worst problem that could result would be the degradation of a major tactical system or capability when needed the most.

Tape control can be divided into the following areas:

- Tape inventory
- Program master/working copies
- Identifying and correcting problems with tapes

TAPE INVENTORY.— Each tape, cartridge, or cassette used in a system must be accounted for by number and have its contents identified by a label. A tape label should contain the system location, program or data designation, unit used to generate the tape, security classification, and date the tape was written. For tapes containing more than one program, a complete listing of all programs, data files, and so forth, should be included in the label.

A written inventory should be maintained indicating programs or data stored on each tape and the security classification of the tape. Tapes containing classified information retain their security classification until properly degaussed or the tape is destroyed.

PROGRAM MASTER/WORKING COPIES.— Tapes, cartridges, and cassettes generally enter a computer system in one of three states:

- New (blank and certified)
- Used (cleaned, blanked, and certified)

- Master tape (operational program, maintenance program, or data file)

Blank tapes, cartridges, or cassettes, and those tapes with data that may be written over are referred to as **scratch tapes.** Those tapes that contain programs or data that is to be saved and protected are known as **master tapes.** You must ensure that master tapes being mounted on or in a unit are protected against a write operation.

The write protection sensors of the tape unit check the mounted tape for a ring, switch, or tab to determine if the contents of the tape are to be protected from a write operation. The write protection circuitry prevents the computer from inadvertently writing over write-protected programs or data.

To prevent the inadvertent destruction of a master tape through operator error or equipment malfunction, you should copy master tapes of programs onto **working copies.** Two working copies should be maintained for each master program in current use.

Only use the master tape to generate new working copies. The working copies can then be used for repeated operations, such as program loading, that will eventually wear down the recording surface of the tape. Use of a master tape as a working copy increases the potential of damage to the tape and loss of data or programs beyond recovery. Upon receipt of new master tapes, the old master tape copies should not be destroyed until the new master tape has proved reliable.

IDENTIFYING AND CORRECTING PROBLEMS WITH MAGNETIC TAPES.— Magnetic tapes used in a system tend to develop a variety of problems. These problems fall into three basic categories:

- Data loss
- Compatibility problems
- Winding errors

Data Loss.— Data written on magnetic tape maybe lost for a variety of reasons. Tapes that are broken, wrinkled, stretched, or are worn, with the oxide flaking off, will not retain data. Excessive heat or cold, or the shock to a tape that is dropped can affect the stored data by rearranging the magnetic flux patterns. Data maybe lost or misread because of accumulations of magnetic oxide particles built up on tape transport read/write heads and mechanics.

When you encounter magnetic tape read or write errors, follow these simple steps:

- Remove the tape from the unit and clean the transport
- If errors persist, attempt to load/write the tape on a different transport
- If the tape is a working copy, make a new working copy by recopying the master to anew tape
- If the tape has visible damage, or if errors follow the tape to different transports, submit the tape for stripping or cleaning/certifying

Compatibility Problems.— Tapes that can be read from one transport and not from another of the same system indicate a problem in the alignment of the system's tape transports. In other words, the transports are incompatible. All tape transports of the same type in a system, or out of any other system, should be compatible. **Compatible** means that all tapes written on a transport can be read without errors by all other transports of the same type and that a transport can read, without errors, all tapes written by other transports of the same type.

Align tape transports to the mechanical and electrical specifications of the manufacturer to ensure compatibility within system transports and the same type transports in other systems.

Winding Errors.— Winding errors are another cause of tape failure. They happen when improper winding practices create excessive or uneven force as the tape is being wound onto a tape reel. The form taken by the tape after it is wound onto a reel is called the **tape pack.** Winding errors can cause a deformed tape pack that will prevent good head-to-tape contact.

In most cases, a deformed tape pack can be corrected simply by rewinding it onto another reel at the proper tension and the right temperature and humidity. The four most common winding errors are cinching, pack slip, spoking, and windowing.

- **Cinching—** Cinching happens when a tape reel is stopped too quickly. The sudden stop causes the outer layers of tape to keep spinning after the inner layers have

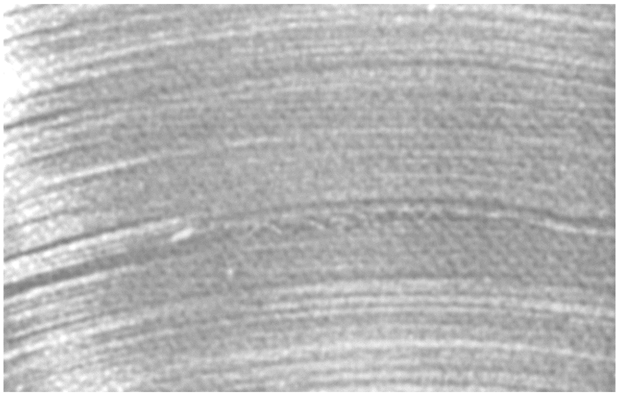

Figure 9-4.—A cinched tape pack.

stopped. Figure 9-4 shows an example of a cinched tape pack (note the complete foldover of one tape strand).

- **Pack slip—** Pack slip occurs when the tape is loosely wound on the reel and exposed to excessive vibration or heat. This causes the tape to shift (side-to-side), causing **steps** in the tape pack. When a tape reel with pack slip is used, the magnetic tape will unwind unevenly and rub against the sides of the tape reel of the tape unit's tape guides. This can damage the tape and cause oxide shedding on the edges of the tape. Figure 9-5 shows an example of pack slip.

- **Spoking—** Spoking occurs when a magnetic tape is wound onto the tape reel with the tension increasing toward the end of the winding. The higher tension on the outside of the tape pack causes the inner pack to buckle and deform. Spoking is also caused by the uneven pressures created when the tape is wound on a distorted hub, or when the tape is wound over a small particle deposited in the reel. Figure 9-6 shows a spoked tape pack.

- **Windowing—** Windows are voids or see-through air gaps in the tape windings. They happen when the magnetic tape is loosely wound onto a tape reel, and especially when the loosely wound reel is later exposed to extreme heat or humidity. Figure 9-7 shows a windowed tape pack.

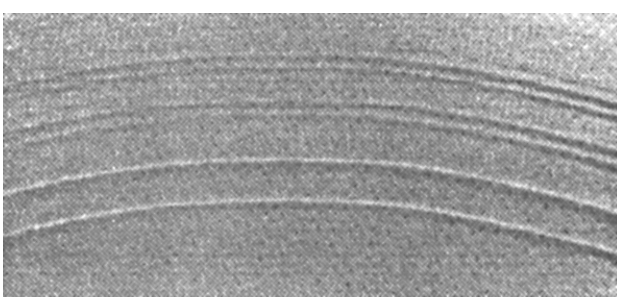

Figure 9-5.—A tape with pack slip.

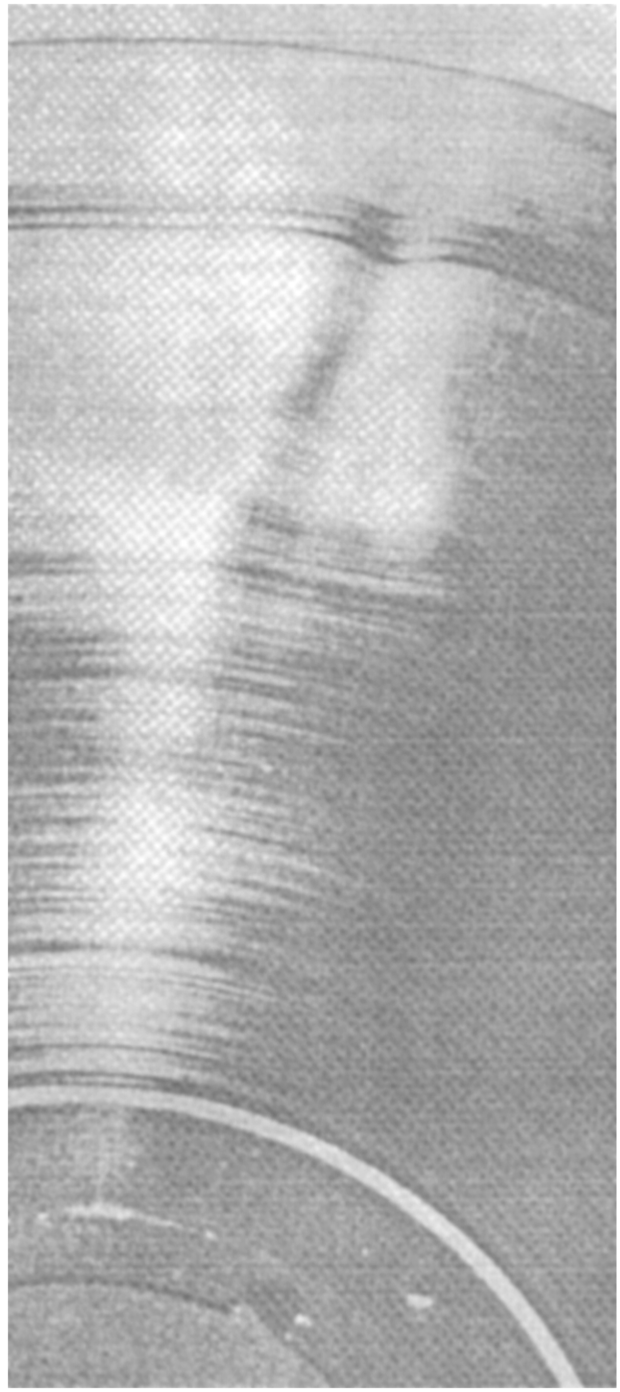

Figure 9-6.—A spoked tape pack.

DATA STORAGE ON MAGNETIC TAPE

Storage of data using magnetic tape units is based on the following principles:

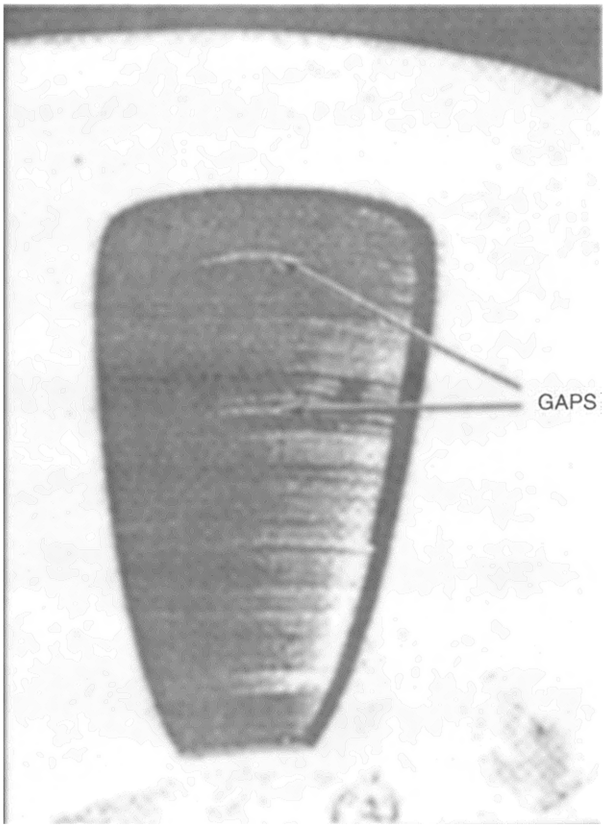

Figure 9-7.—A windowed tape pack.

- Current flow in a conductor can be generated by a change in the magnetic lines of force that cut through a conductor

- Changing the current flow in a conductor creates a change in the magnetic lines of force radiating from the conductor

In other words, you can create current flow by rotating (moving) a conductor in a magnetic (or electromagnetic) field or by changing the distance between a conductor and the source of magnetic flux (field lines).

These principles allow for the creation of a magnetized spot (flux pattern) on a magnetic material (magnetic oxide surface). The magnetized spot is created by the magnetic field surrounding a current-carrying conductor in the immediate proximity to the material. Moving the magnetized spot rapidly by a conductor will generate current flow in the conductor. Thus data may be written on the surface of a magnetic material as it moves under a current-carrying conductor (write head); data may be sensed from the magnetized surface as it passes under a conductor (read head) and generates current.

Recording Methods

The direction of the magnetic flux patterns written on the magnetic oxide surface maybe used to represent **binary** values. In other words, a flux pattern magnetized in one direction might indicate a binary ZERO, while a pattern magnetized in the opposite direction would indicate a binary ONE. This method of recording data is known as the **return-to-zero (RZ)** recording technique.

Another recording method changes the direction of the flux pattern when a binary ONE is to be stored. When data is read from the magnetic oxide surface, a change influx pattern direction indicates a binary ONE, while no change indicates a binary ZERO. This method of recording data is known as **non-return-to-zero (NRZ).** NRZ is more commonly used than RZ because it lends itself to higher bit densities on the recording surface.

A third recording method found in many newer devices is known as **phase encoding (PE).** This method uses very narrow spikes of current to write extremely small flux patterns on the magnetic oxide surface. Very accurate timing pulses are required to read PE data spikes from the magnetic oxide surface. The PE recording method provides the highest data density of any recording method commonly in use.

Writing/Reading Magnetic Tape

The purpose of any magnetic tape unit is to write data on and read data from the tape used by the device. Tape is moved from a supply reel or hub to a take-up reel or hub on the magnetic tape transport section of the unit as shown in figure 9-8. The magnetic oxide coated side of the tape passes in close proximity of a read/write

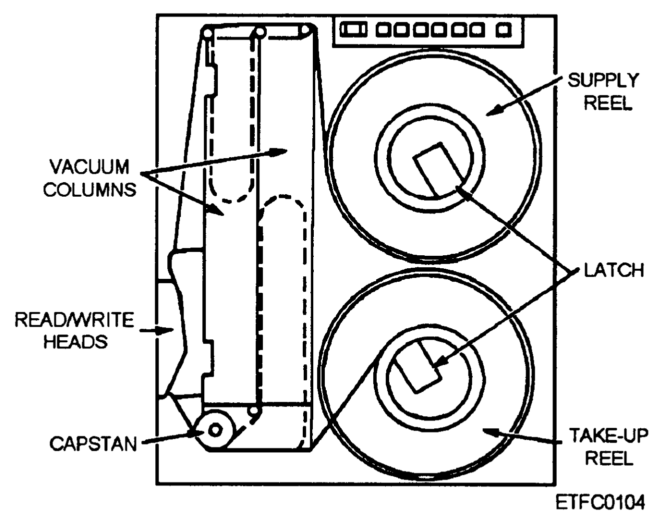

Figure 9-8.—A magnetic tape transport

head or group of read/write heads. The moving tape can then have data written upon it as is shown in figure 9-9. Data may be read from tapes having information stored on them.

Each individual write head can store data one bit at a time along an invisible line on the tape called a **track.** The number of bits written per inch of track (bpi) is one of the factors used to determine the **density** of data on the tape. An industry standard 0.5-inch tape may have seven or nine tracks of data stored on it.

Data Organization and Timing

The read/write heads of magnetic tape devices are usually designed to write and read data concurrently across the width of the tape. This grouping of bits is known as a **frame.** On multitrack tapes, density is determined by the number of frames per inch (fpi) instead of bpi for a single track. Common densities for multitrack tapes range from 200 to 1,600 fpi. Most magnetic tape devices are capable of writing and reading several different fpi densities.

A frame of data on a seven-track tape consists of six data bits, and a check (parity) bit. A nine-track frame has eight data bits, and a parity bit.

Frames are determinedby the a shift of the magnetic field in any bit position within the frame. With the proper combination of parity checking (odd parity) and data, at least a single binary ONE is stored in each frame. Using the NRZ recording method, every frame contains at least a single binary ONE. The presence of a ONE, when detected by any read head, will indicate the presence of a frame. This recording method is known as **non-return-to-zero indiscrete (NRZI).**

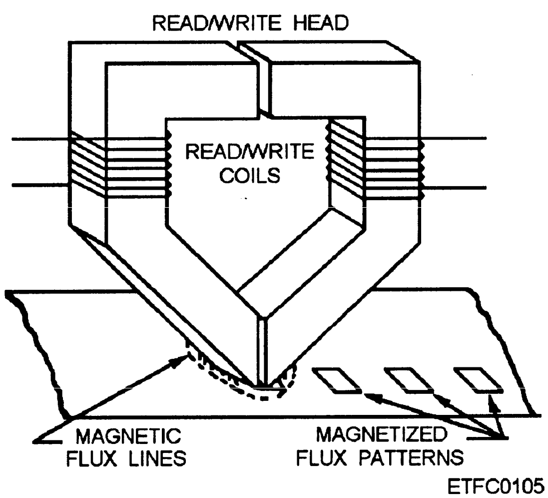

Figure 9-9.—Writing data on magnetic tape.

Magnetic Tape Markings

Magnetic tapes have many common features and data recording formats. Each tape is marked, in some manner, at **beginning of tape (BOT)** and at **end of tape**

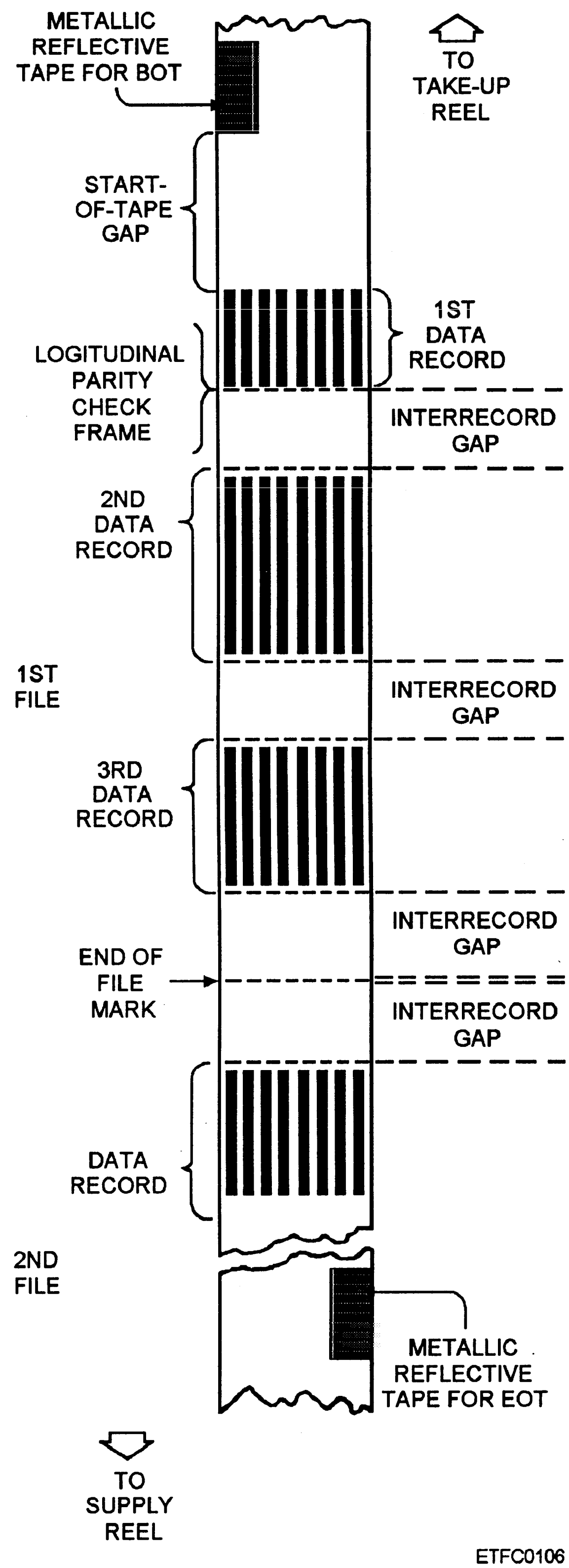

Figure 9-10.—A magnetic tape layout

(EOT). The length of tape between BOT and EOT is refereed to as the **usable recording surface** or usable storage area.

BOT/EOT markers are usually short strips of reflective tape, as shown in figure 9-10. BOT is the common starting point used in a system when writing or searching for data on tape. Holes punched in the tape or clear plastic inserts are used as markers in some units. BOT/EOT markers are sensed by an arrangement of lamps and photodiode sensors as shown in figure 9-11.

Data Records on Tape

One factor all magnetic tapes have in common is that the tape must be moving at a predetermined speed for data to be written on, or read from, the tape. In other words, data cannot be written or read while the tape is starting to move, stopping movement, or stopped.

This **start/stop** effect creates a blank spot on tape until the tape is up **to speed** and can be written on. In addition, these blank spots, or **gaps,** are used to separate blocks of data or **records** on tape. Gaps separating records are known as **interrecord gaps.** Refer to figure 9-10.

A record is nothing more than a group of contiguous frames. The number of frames needed to store the desired data determines the size of the record. The size of a record may vary from a few frames to the entire length of the usable recording surface. Record length is a function of **software** (computer programs), not of the magnetic tape device.

Data Files on Tape

Most magnetic tape devices provide for the identification of **files** of data. Such identification provides greater flexibility in the handling and processing of large amounts of data. A data file is nothing more than a group of records. Frames makeup records, records make up files. Files are separated by special identifying frames known as **file marks, end-of-file marks,** or **tape marks.**

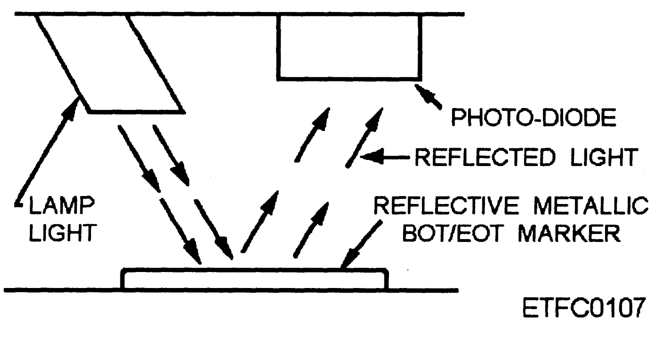

Figure 9-11.—A BOT/EOT sensor.

File marks are located at the end of each data file on the tape. The first file starts after the start-of-tape gap, as shown in figure 9-10. Notice the organization of records and interrecord gaps within the file. The second file starts after the first file mark. Following files will each end in a file mark

Parity Checks

What are known as **lateral parity** and/or **longitudinal parity** are common methods of ensuring the accuracy of data recorded on tape. Lateral parity checks use each frame's **parity bit.** Longitudinal parity checks use a special frame located at the end of each record.

The two types of parity formats are **odd parity** and **even parity.** Each of the data bits in a frame is written as a ONE or a ZERO. Parity checks count the number of binary ONES in the frame and store a ONE or ZERO in the parity check bit to keep the total number of ONEs in the frame **odd** or **even.**

As an example of odd parity, the six data bits to be written as a frame (seven-track) consist of 010 011. Three ONEs are in this frame. The total number of ONES in the frame is already odd, so the parity bit will be written as a ZERO. If the number of ONES in the data bits were even (01 1 110), then the parity bit would be written as a ONE to maintain odd parity. Odd parity is commonly used with NRZI recording to distinguish frames while reading. Since every frame will have at least a single binary ONE, a flux change sensed on any track indicates a frame.

As the frame is read from tape, the ONES in the data bits read are summed; the result is compared with the parity bit read. If the parity bit written on tape matches the comparison bit, then the frame is assumed to contain the correct data. If the comparison bit does not match the parity bit written on tape, then a **parity error** has occurred.

Lateral parity checks are designed to locate the loss or addition of one bit of data in a frame. They are one of the most common fault indications encountered by technicians working on magnetic tape devices. Parity errors can result from a variety of mechanical, electrical, and environmental problems.

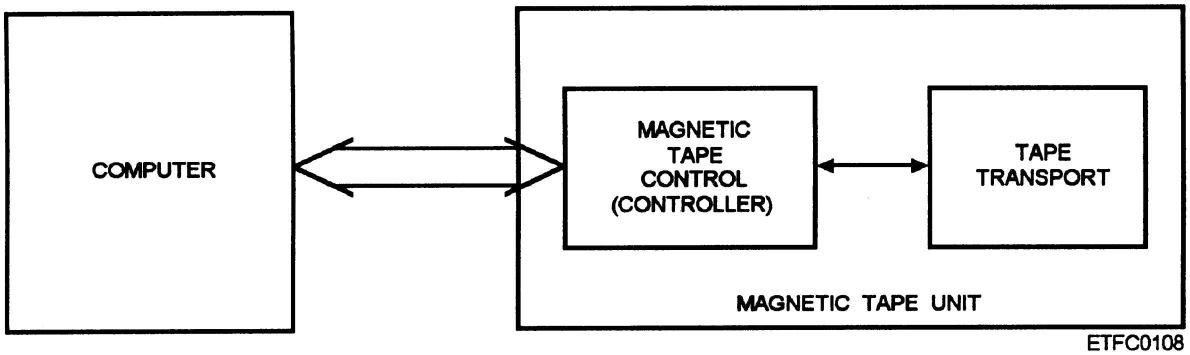

Figure 9-12.—A magnetic tape storage device functional block diagram.

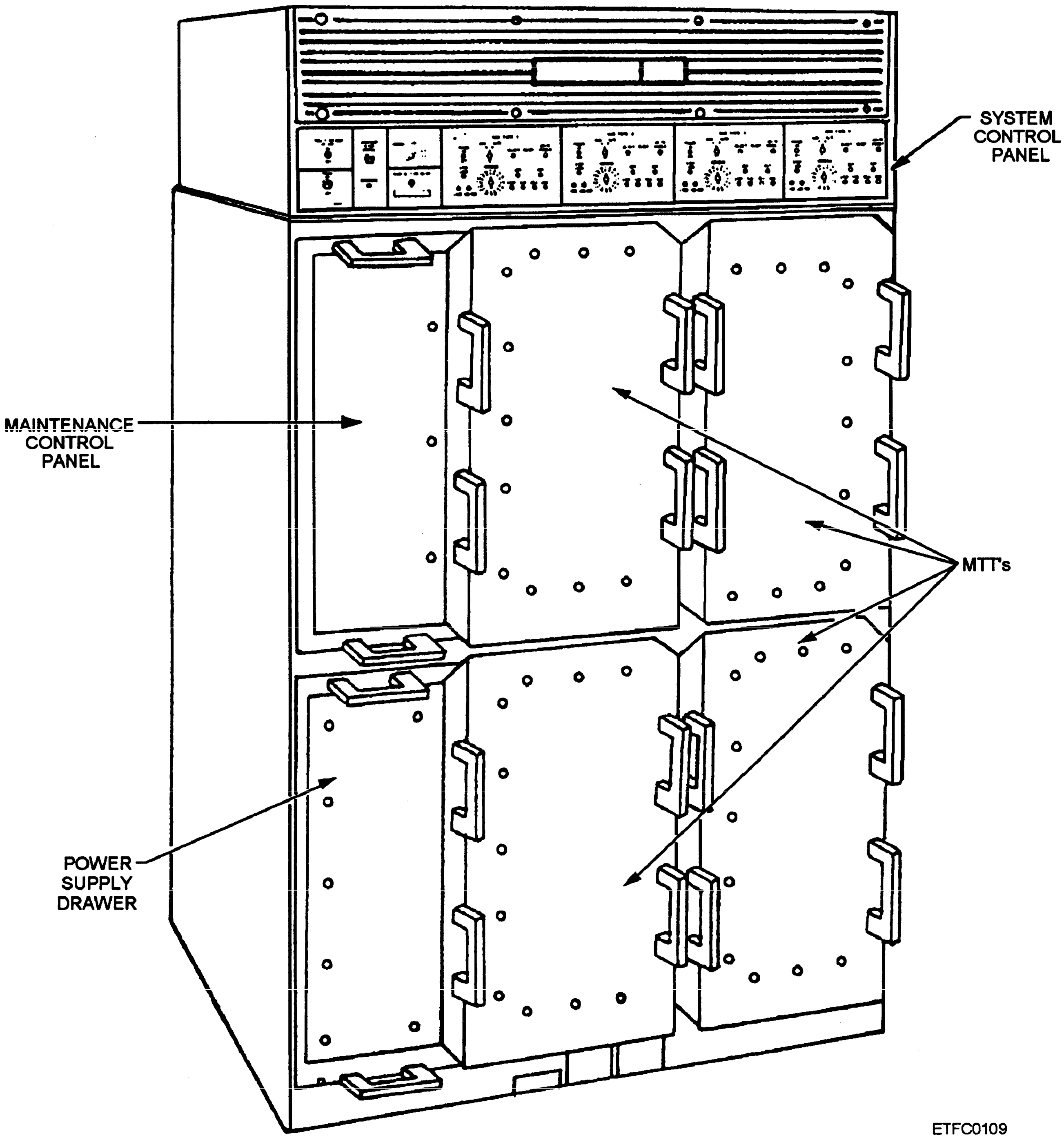

Figure 9-13.—A magnetic tape unit.

In addition to lateral parity, many units use a longitudinal parity check. A special **check frame** is written after the last data frame of each record. This frame, as shown in figure 9-10, contains the parity bits for the sum of all the ONES written in each track. In other words, each bit of the check frame is a parity bit for that track of data. Longitudinal parity checks help identify errors to the specific track or bit position on tape.

TOPIC 2—MAGNETIC TAPE DEVICES

Magnetic tape storage devices can be divided into two functional areas, as shown in figure 9-12:

- Magnetic tape control or controller
- Tape transport

Now let's take a look at a typical magnetic tape unit and its associated tape transport. This unit is based on the RD-358(V)/UYK Magnetic Tape Unit, but is a compilation of several tape units. Specifications used may or may not be the same as the magnetic tape unit at your command and are intended only to help you get a more detailed understanding of the electronic and electromechanical nature of magnetic tape units.

The magnetic tape unit (MTU), shown in figure 9-13, provides auxiliary (secondary) data storage for one or two computers (duplex operation). The tape unit is used primarily for operational and maintenance program loading for the combat direction system (CDS). It is also used to record real-time data extracted from the CDS, to copy maintenance and operational program tapes, and to patch or modify maintenance and operational program tapes.

This MTU can control up to four magnetic tape transports (MTTs). Standard shipboard configurations consist of two or four transport units. The MTTs use 0.5-inch, A-wound (oxide coating on the underside of the tape as it is wound on the reel), polyester-based magnetic tape wound on industry standard open reels. The MTTs are single-capstan, vacuum-column tape drives as shown in figure 9-14.

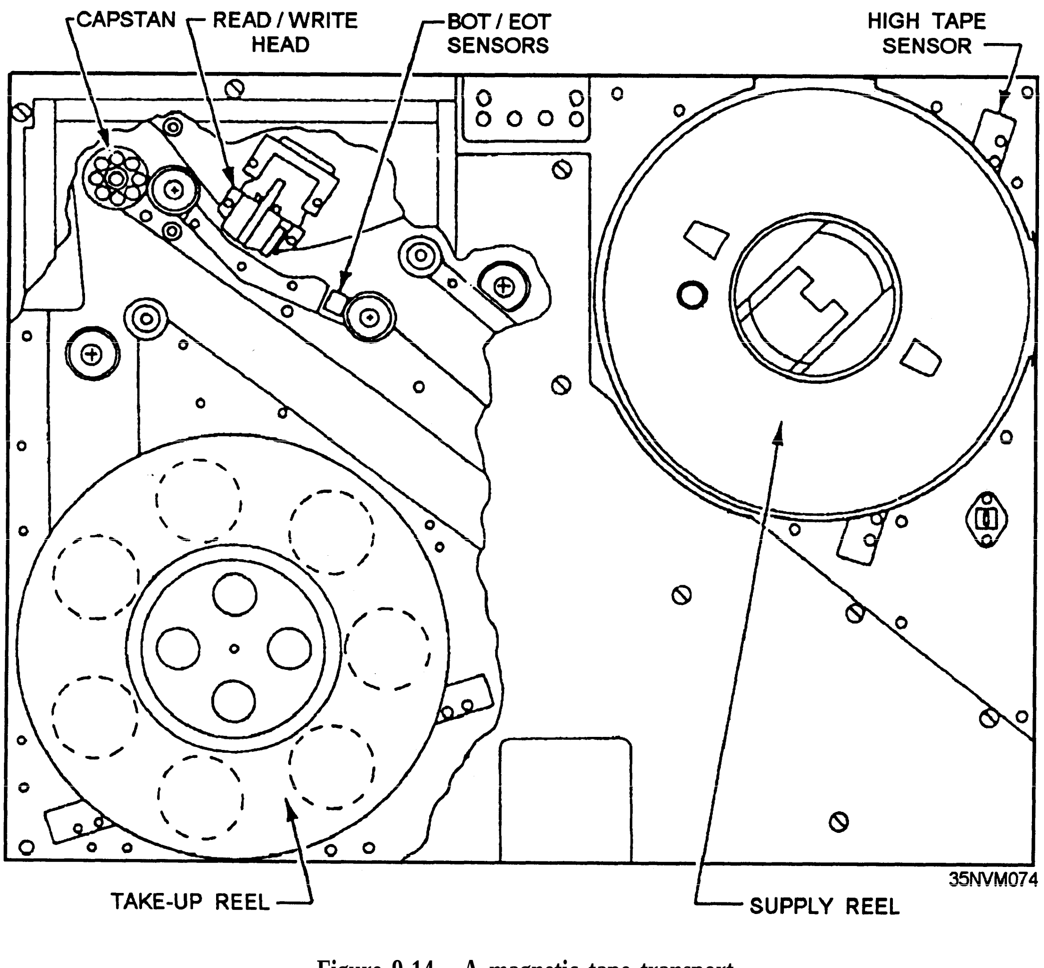

Figure 9-14.—A magnetic tape transport.

MAGNETIC TAPE CONTROLLER

Common functions performed by the magnetic tape control section are as follows:

- Receives data and commands (external functions) from one or more central processors (computers)
- Provides timing and control signals to one or more tape transports for read, write, search, and rewind operations
- Reformats computer words received from the central processor into frame-size bytes, generates parity bits for each frame, and transmits frame data to the write heads (write operation)
- Receives frames of data from the tape transport read heads, checks for parity errors, and formats data into computer words for the central processor (read operation)
- Receives status signals from one or more tape transports and monitors tape movement
- Transmits data and unit status (status words) **to** the central processor

MAGNETIC TAPE UNIT OPERATIONS

The magnetic tape unit is capable of performing several operations such as read (forward and reverse), write, and rewind. Operations can be performed online or offline.

MTU Online Operations

Typical operations performed by the MTU while under computer control (online) include the following:

- Read
- Write
- Space file
- Rewind

MTU READ/WRITE OPERATIONS.— Read and write densities on most MTUs are selectable. The density selected depends on the operational mode selected, the installed options, and the number of tracks used to record and read data.

The NRZI recording format is the most common recording method used for seven- and nine-track operations up to densities of 800 fpi. For 1600 fpi, nine-track operations, PE recording/reading is used.

MTU READ/WRITE TAPE SPEED.— All read operations, including search and space file, and write operations are performed at a tape speed of 120 inches per second (ips). Data may be read in the forward or reverse directions, but it may be written only in the forward direction.

MTU WRITE PROTECTION.— Protection of master tapes is provided by the use of a write-enabling ring and sensing circuitry in the MTTs. Only tapes with a write-enabling ring installed, as shown in figure 9-15, may be used in the write operation. Tapes without a write-enabling ring are protected from the write operation.

MTU SEARCH.— In the search operation, the controlling computer provides a single word code known as the **search key** to the MTU. The MTU then performs a record-by-record search of the tape on the MTT selected. The first data word of each record is compared to the search key. If they match, a **find record** condition exists; the record is then read normally and transmitted to the controlling computer. If no match is found, then the unit will continue searching records until EOT or BOT is detected.

SPACE FILE.— The space file operation is used to find a tape mark, which should indicate the start of a file. The selected MTT moves tape, under the direction of the MTU, until a tape mark is detected. Tape motion is then stopped with the read head over the interrecord gap following the tape mark. Tape marks are not normally found in front of the first file on the tape.

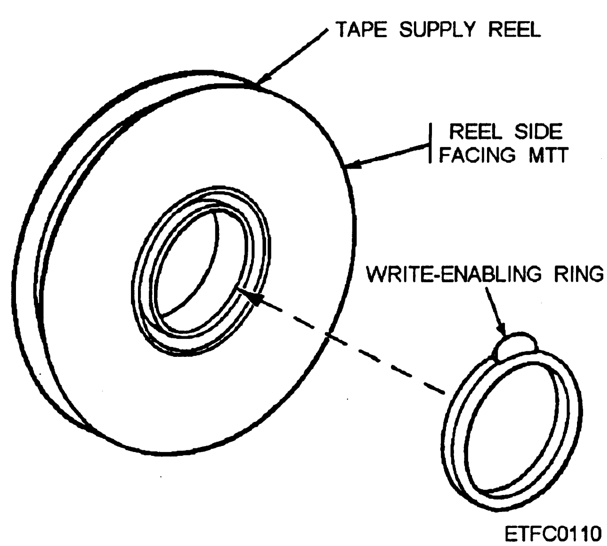

Figure 9-15.—A write-enabling ring.

REWIND.— The rewind operation consists of reverse tape movement at 200 ips. Tape movement is slowed to 120 ips when less than 100 feet of tape (low tape) remains on the take-up reel. Tape movement is stopped upon detection of BOT marker.

MTU Offline Operations

You can operate the MTU offline using the maintenance panel. The maintenance panel pushbuttons can be used to generate all operational commands and the indicators monitor the results of these operations. In addition, some MTUs contain an internal microprogrammed controller (MPC) read-only memory (ROM). MTUs with an MPC ROM can be programmed by the manufacturer to peform internal diagnostic programs, offline operations, such as tape to printer, tape to card punch, and card reader to tape.

MTU Functional Description

A typical MTU is divided into the following functional areas as shown in figure 9-16:

- Control unit (CU)
- System control panel
- Maintenance panel
- Magnetic tape transports (MTTs) 1 through 4

CONTROL UNIT.— The control unit contains the logic required to control the various functions of the magnetic tape unit and to peform the tasks required by the external computer(s). At the heart of the control unit is the MPC. The MPC acts as a data switch and controller for all data transfers and other operations within the tape unit. The MPC is a microcomputer with arithmetic and control capabilities.

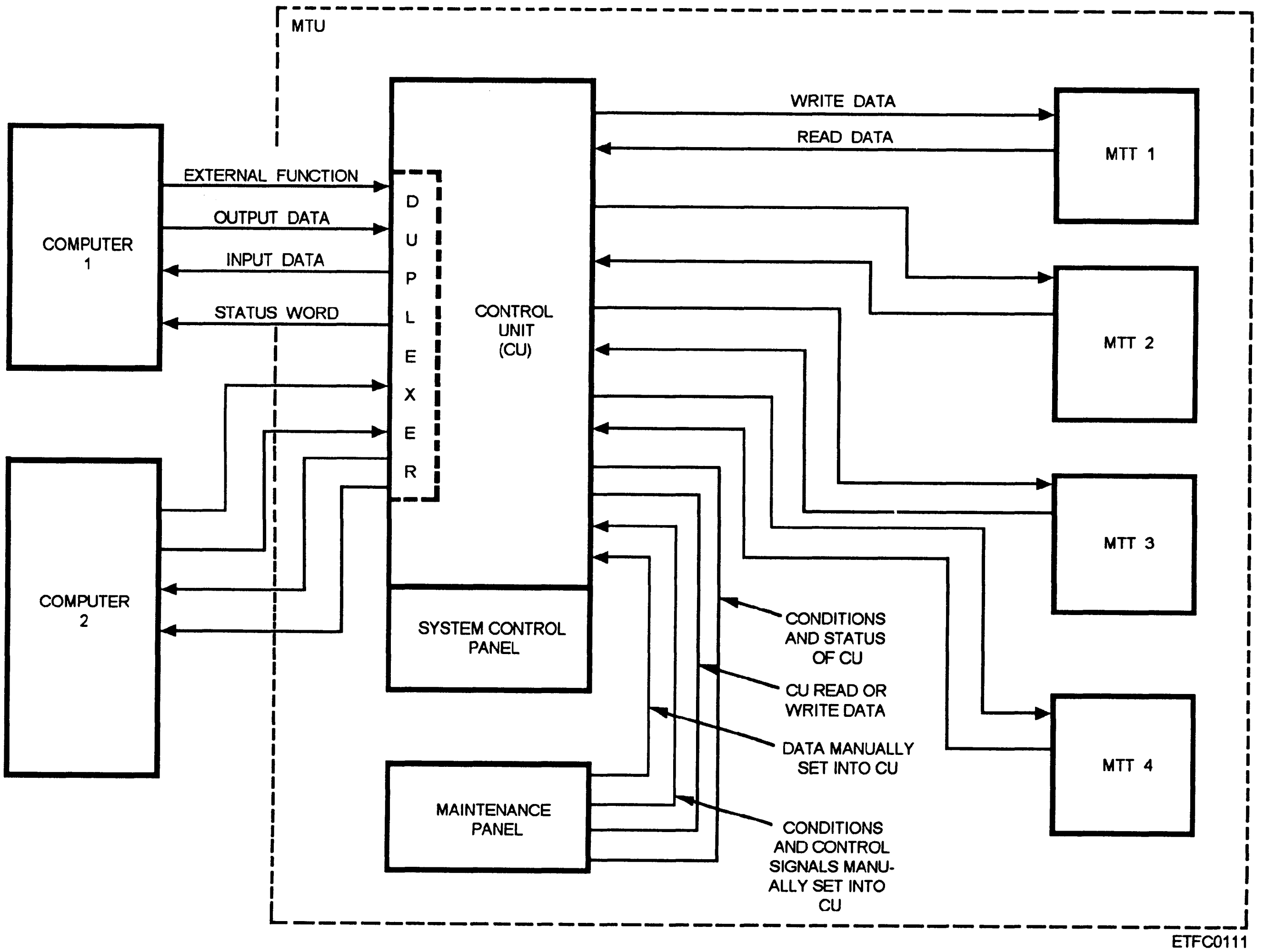

Figure 9-16.—An MTU functional block diagram.

The program for the MPC is stored in ROM. The sequence of instructions obtained from the ROM, by the MPC, determines what, when, and how events will be done in the MTU. All computation, such as parity checks or operational decoding of external function words, is performed by the MPC.

Two data buses, the source bus and the destination bus, are used for data transfer to and from the MPC. The MPC receives data via the source bus and transmits data via the destination bus. The source and destination of data are determined by ROM program instructions.

The MPC performs the following functions within the control unit:

- Interprets external function commands received from the external computer(s)
- Converts computer data to tape frames as specified by external function words (write operation)
- Converts tape frames to computer data as specified by external function words (read operation)
- Forms status words for the external computer(s)
- Initiates start/stop delays
- Determines frame lateral parity bit, and checks for lateral parity errors
- Forms longitudinal parity check fumes, and checks for longitudinal parity errors
- Peforms comparisons for search operations
- Checks frame count for lost frames
- Detects end of records
- Detects input (write) and output (read) timing errors
- Performs cyclic redundancy checks
- Selects MTT

The remaining elements of the control unit provide the communications links between the MPC and the external computer(s), and the MPC and the MTTs. Additional functions performed by the control unit circuitry include the following:

- Read/write signal amplification (to/from MTT read/write heads)
- Deskewing (frame alignment)
- Density selection, control, and timing
- Time delays (start/stop)
- Dual computer operation control (duplex)
- Computer electrical interface matching
- Offline channel interface and timing

MTU SYSTEM CONTROL PANEL.— The system control panel, as shown in figure 9-17, contains the controls and indicators for primary power and tape transport manual control. Controls and indicators for the controller include the main power circuit breaker, mode select, overtemp alarm, and overtemp alarm bypass. Controls and indicators for each tape

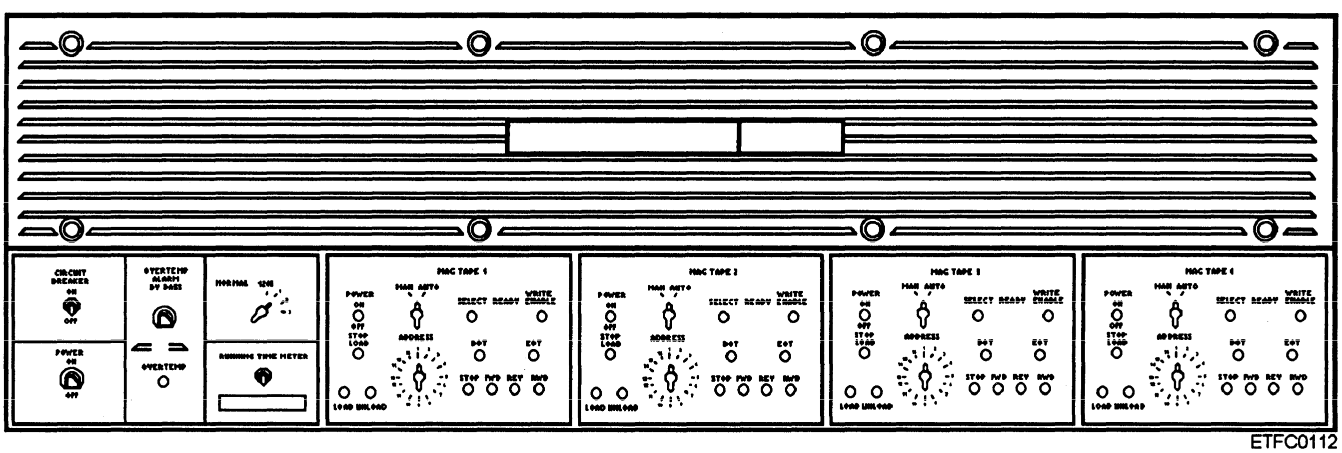

Figure 9-17.—An MTU system control panel.

transport include the tape transport power on/off switch, address select switch, write enable switch, load tape switch, unload tape switch, ready indicator, select switch, BOT and EOT indicators, and tape movement switches.

MAINTENANCE PANEL.— The maintenance panel, as shown in figure 9-18, contains the controls and indicators used for manual offline operation and testing of the MTV.

MAGNETIC TAPE TRANSPORT (MTT)

The magnetic tape transport (MTT) contains all the electromechanical components necessary for the physical handling of the magnetic tape. These components include:

- Reel and capstan drive motors
- Tape guides
- Reels and hubs
- Sensors (BOT/EOT, write protection, low tape, and so on)
- Vacuum columns
- Read/write and erase heads

The tape transport commonly performs the following functions:

- Automatic tape loading/loading
- Bidirectional movement of magnetic tape (forward, reverse, or rewind)
- Sensing of BOT/EOT markers, write-eabling rings, low tape, and soon
- Writing multitrack data on tape
- Reading multitrack data from tape
- Basic Tape Transport Operation

Movement of tape on a tape transport is dependent on the tape reels, the vacuum columns, and the capstan.

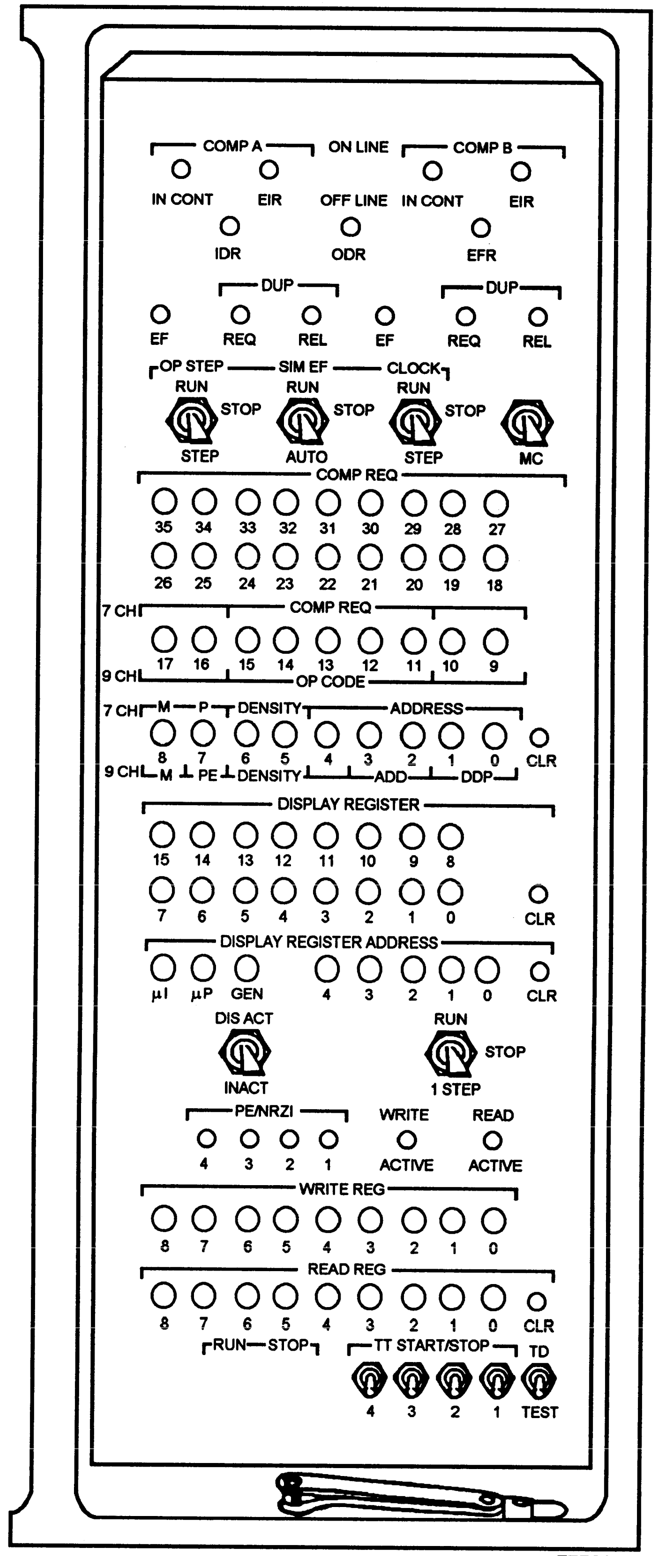

Figure 9-18.—An MTU maintenance panel.

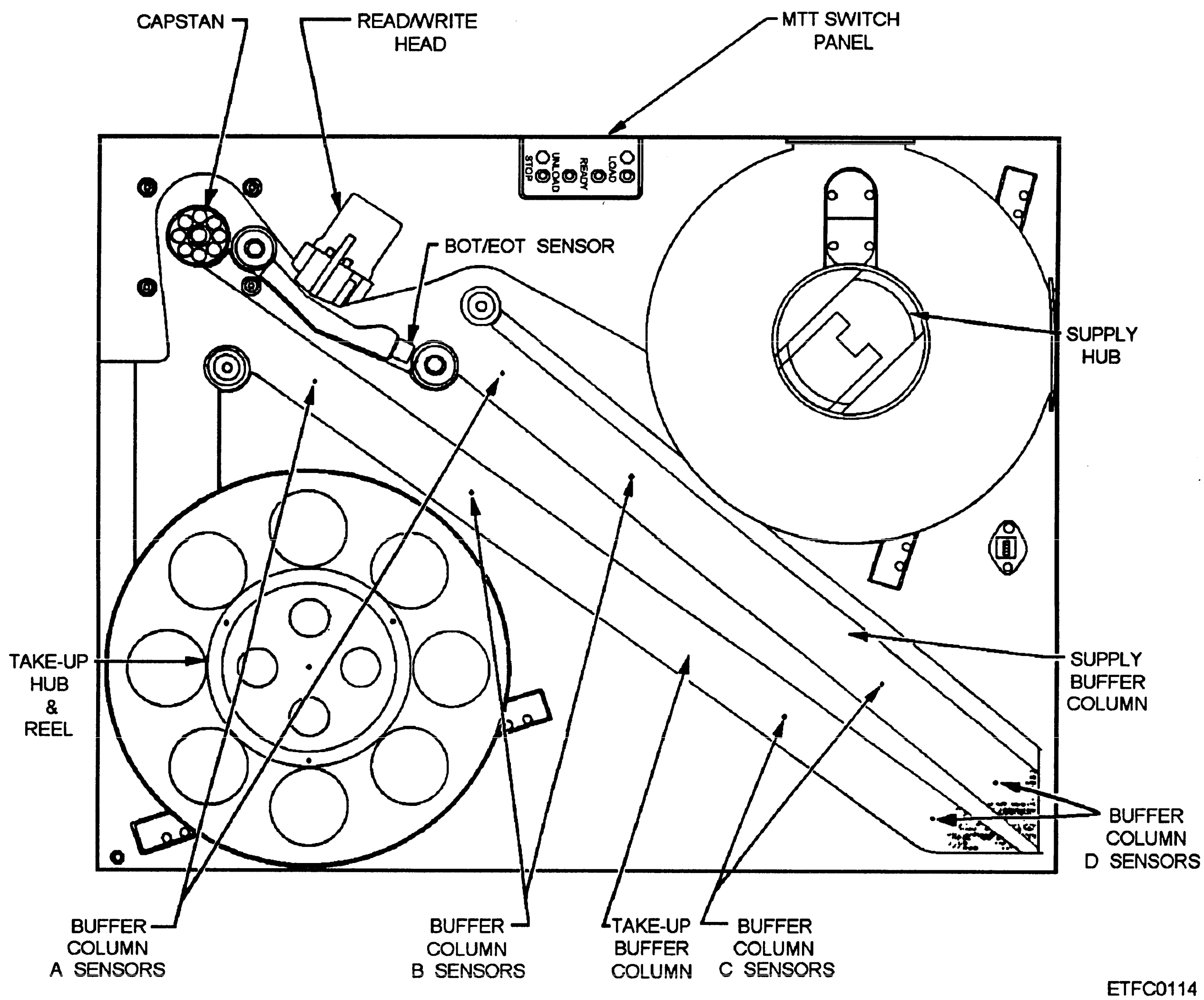

Figure 9-19.—A magnetic tape transport, detailed view.

Figure 9-19 shows a common form of tape transport. The supply and take-up reels are mounted on servo-driven hubs. The tape is guided from the supply reel through the supply vacuum column, under the read/write head, over the capstan, through the take-up vacuum column, to the take-up reel.

Loops of tape are formed in the vacuum columns during the loading process. The size of the tape loop in the vacuum column determines the direction of rotation of the servomotor-driven reel that corresponds to the column (supply/take-up).

The capstan determines the direction and speed of tape movement under the read/write head assembly. The capstan is driven by a bidirectional motor so that it may rotate in either direction. When tape motion is desired, the capstan is rotated in the desired direction. Natural friction or vacuum applied through holes in the capstan pulls the tape in the desired direction at the correct speed. Tachometers are often used to sense for correct tape speed and to control capstan speed.

As the capstan pulls the tape, tape is "taken up" from one vacuum column, and "payed out" into the other. Tape position in the columns is sensed by pressure-sensitive switches or photodiode assemblies. As one column is being emptied of its tape loop, the corresponding servo-driven reel pays out tape to maintain the correct tape loop. As the loop in the opposite column grows larger, the corresponding servo-driven reel takes up tape, once again maintaining the correct size loop. The locations of loop sensors in the vacuum column and servo-hub response are shown in figure 9-20.

The MTT must be connected to the MTU control unit and power supply for the necessary operational commands and power.

MTT Block Diagram

The MTT can be divided into the following functional areas, as shown in figure 9-21:

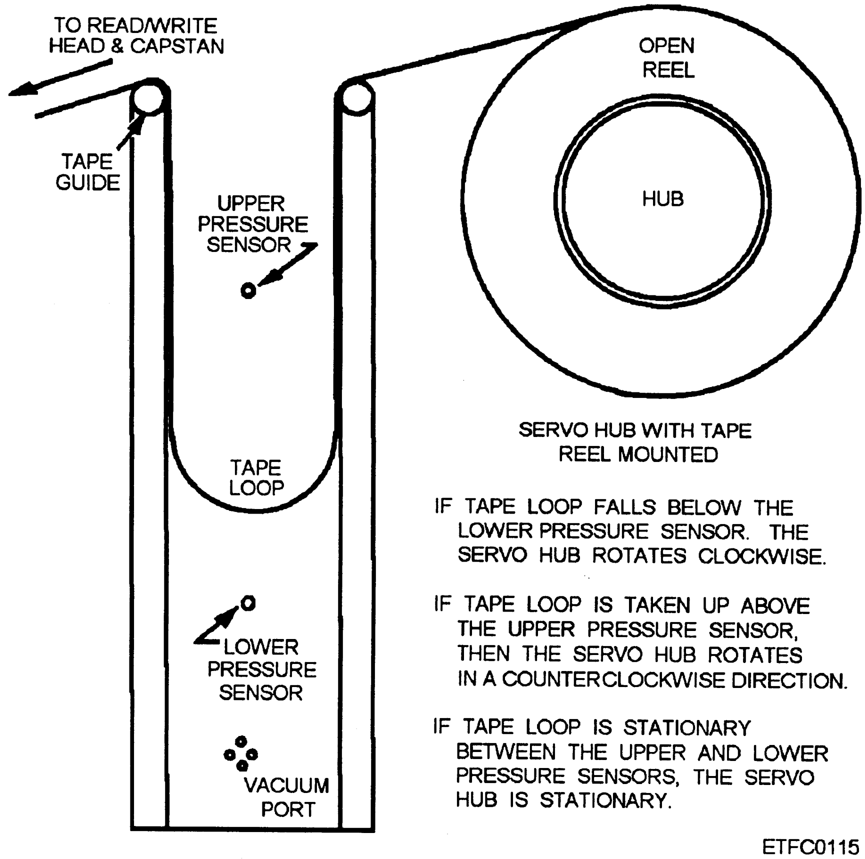

Figure 9-20.—A vacuum column/servo hub.

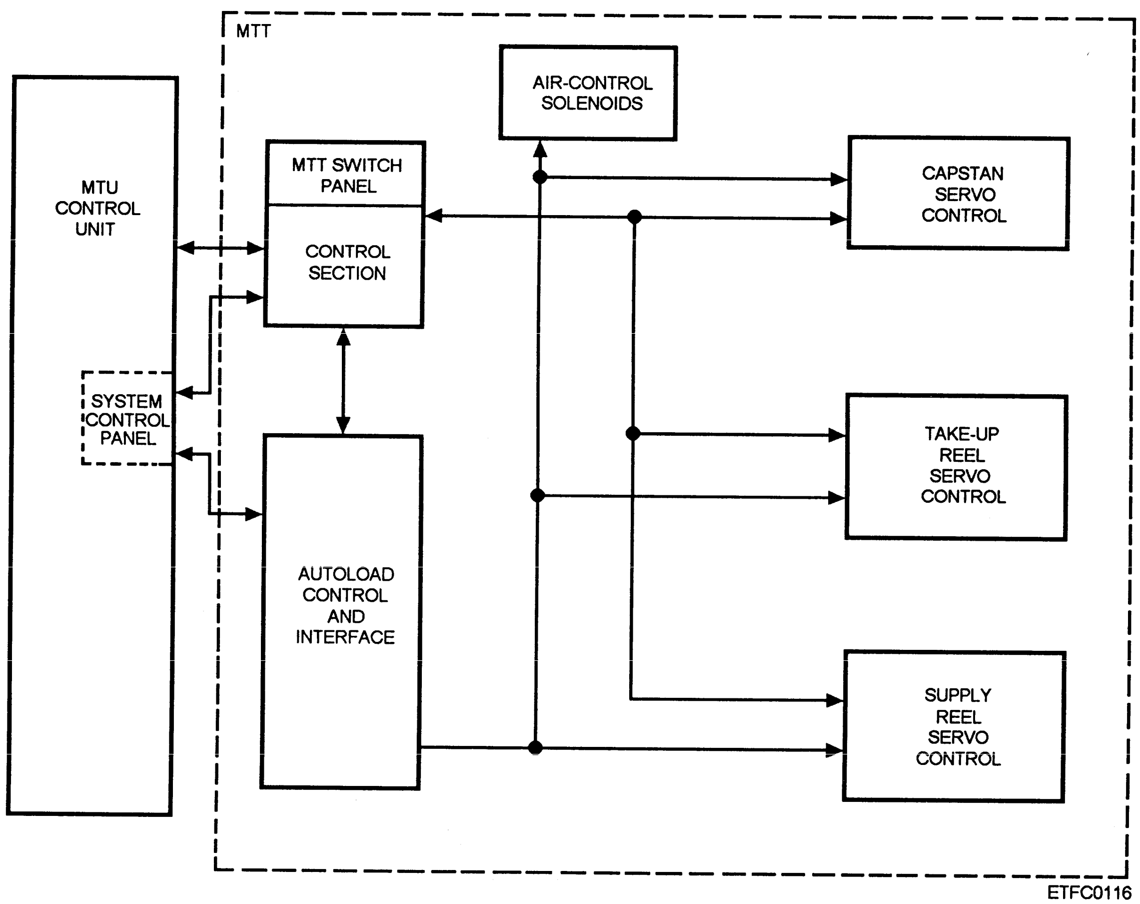

Figure 9-21.—An MTT functional block diagram.

- Control section
- Autoload control and interface circuitry
- Air-control solenoids
- Capstan servo control
- Take-up reel servo control
- Supply reel servo control

CONTROL SECTION.— The control section provides the control signals for manual operation of the MTT. It lights the MTT switch panel indicators (LOAD, UNLOAD, and STOP) and remote system control panel indicators to notify the MTT operator of operational status. In addition, the control section acts as an interface for MTU control signals and status responses.

AUTOLOAD CONTROL AND INTERFACE.— The autoload control and interface section provides the function signals for controlling the sequential operations of the automatic loading process. It provides operator status indications to the system control panel and MTT switch panel. It also provides status of the transport to the MTU control unit via the control section.

This section also provides timing pulses and servo-movement control signals to the capstan, air-control solenoids, and reel servo-control sections during the autoloading process.

AIR-CONTROL SOLENOIDS.— The air-control solenoids (Air 1 and Air 2) control the application of vacuum and air pressure during the loading process and during normal operation. Air 1 is energized during the first portions of the autoload operation to apply pressure to the buffer columns. This prevents loops from forming in the columns as tape is fed to the take-up reel. When the tape reaches the take-up reel, Air 2 is energized to apply a vacuum to the take-up reel to cause the tape to adhere to the reel. Once the tape adheres to the take-up reel, then Air 1 and Air 2 are deenergized. When they are deenergized, vacuum is applied to the buffer columns through the vacuum ports. This forms the loops of tape in the columns for normal operation.

CAPSTAN SERVO CONTROL.— The capstan servo-control circuitry controls the direction and speed of the capstan. The purpose of the capstan is to move the tape forward at 120 ips and in reverse at 120 or 200 ips. The 120-ips speed is used for reading and writing in the forward direction and reading in the reverse direction. The 200-ips speed is used primarily to rewind the tape. The capstan is slowed to 120 ips when less than 100 feet of tape remains on the take-up reel (low tape). A special feature allows for fast forward or reverse tape movement (200 ips) under direction of the MTU control unit.

The capstan controls tape movement. The reel servo-control systems only respond to or assist in the movement and stopping of the tape. The capstan is connected to a tachometer that feeds capstan velocity to the reel servo-control sections.

SUPPLY REEL SERVO-CONTROL SECTION.— The supply reel servo-control section controls the movement of the supply reel hub. Hub motion depends on capstan direction and velocity, reel tachometer input, and vacuum/pressure sensors in the supply buffer column.

Four vacuum/pressure sensors are located in the supply buffer column. These sensors (labeled A, B, C, and D in fig. 9-19) locate the tape loop within the vacuum (buffer) column. Sensors B and C are called control sensors. During normal operation, the tape loop is between sensors B and C in the column. The servo-driven hub attempts to keep the loop between sensors B and C at all times.

Sensors A and D are called fault sensors. If the tape loop reaches above sensor A or below sensor D, a fault condition is indicated. A fault condition removes the tape transport ready status and stops tape movement.

At the mouth of the supply buffer column(fig. 9-19) is the reel tachometer. The reel tachometer assesses the speed of the tape being fed into or taken out of the supply buffer column. The speed of the reel tachometer is compared to the speed of the capstan tachometer. The greater the difference, the greater the change in the speed of the servo-driven hub as it responds.

TAKE-UP REEL SERVO-CONTROL SECTION.— The take-up reel servo-control section is identical to the supply reel servo-control section.

CARTRIDGE MAGNETIC TAPE DEVICES

Cartridge magnetic tape devices perform the same functions as standard magnetic tape unit controllers and transports. The cartridge contains a mechanical system of belts, guide rollers, and capstans as shown in figure 9-22.

The cartridge is inserted into the applicable unit, which contains the controller and the read/write heads, drive roller, and sensors of the unit. The

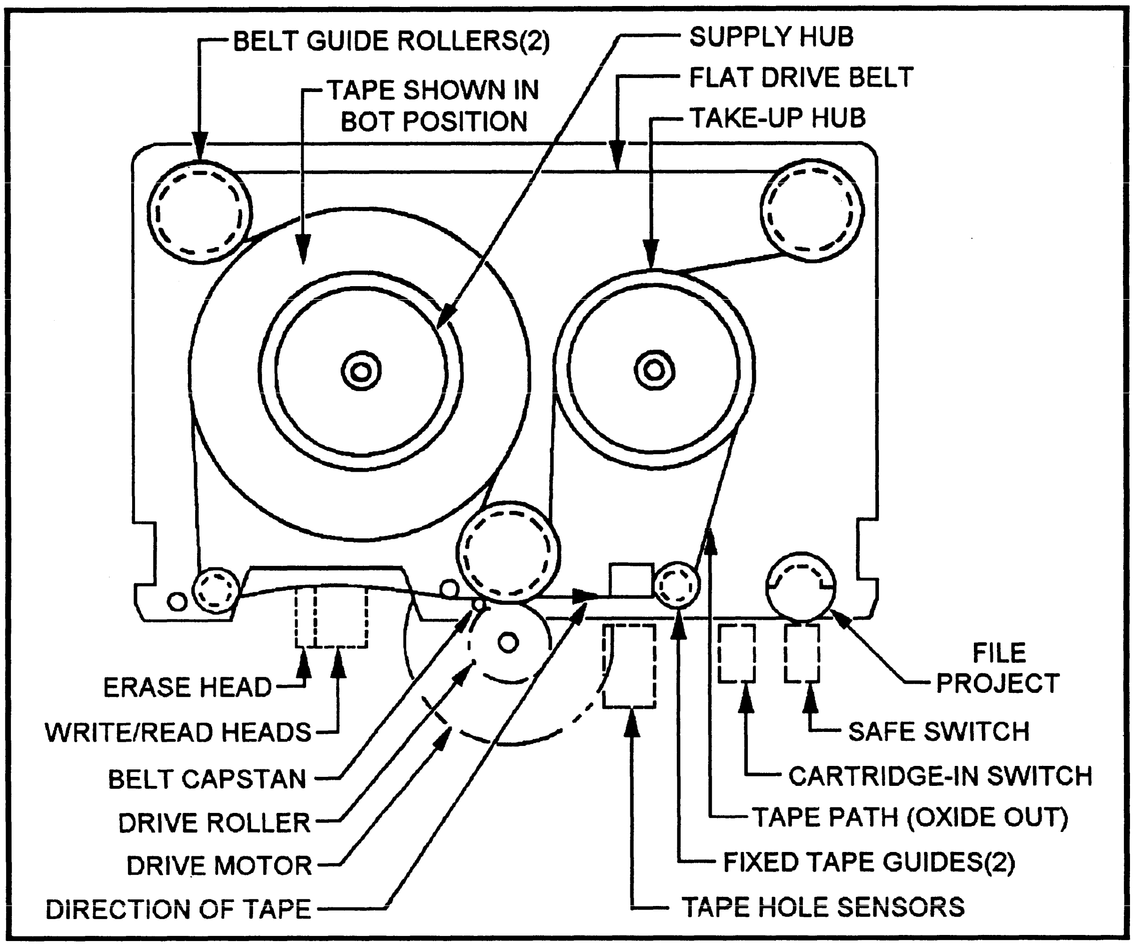

Figure 9-22.—A magnetic tape cartridge.

standard cartridge uses 600 feet of 1/4-inch tape. Instead of reflective markers, holes punched in the tape are used to indicate BOT/EOT.

The unit contains four read/write heads. Data may be written on or read from four addressable tracks (0, 1, 2, or 3). Separate data maybe stored in each track, or tracks may be used as a continuation of the previously selected track. Data is stored serially one bit at a time down the length of the track. Up to 60 megabytes of data may be stored on one 600-foot cartridge.

Cartridge units are slower than standard tape drives, but the cartridges are more rugged and easily transported. In addition, the cartridge unit has less moving parts than the standard tape drive, which contributes to increased unit reliability and maintainability.

TOPIC 3—MAINTENANCE REQUIREMENTS

Preventive maintenance of magnetic tape devices consists of performing mechanical and electrical alignments and testing the tape units using several different maintenance programs.

ALIGNMENT

Magnetic tape units require many mechanical and electronic adjustments/alignments. Some of these adjustments are required only during unit installation. Others must be done when a faulty component or assembly is removed and/or replaced. Still others are needed because of normal equipment usage (wear and tear).

Alignment checks or adjustments required on a periodic basis are covered by the Planned Maintenance System (PMS) Maintenance Index Page (MIP) and Maintenance Requirement Cards (MRCs) that apply to the unit you are maintaining.

You may find nonperiodic adjustment procedures or technical specifications for periodic alignment checks in the technical manual for the magnetic tape device in your system.

DIAGNOSTIC PROGRAMS

The following three types of test (diagnostic) programs are available for most magnetic tape units:

- Internal diagnostics
- The programmed operational functional appraisal (POFA) for the MTU in your system
- The MTU peripheral equipment functional test (PEFT)

Internal Diagnostics

Internal diagnostic tests are controlled by the MPC ROM. For periodicity and procedures, look in the PMS MIP and MRCs.

Programmed Operational Functional Appraisal (POFA)

The programmed operational functional appraisal (POFA) tests are run under the control of a stand-alone computer. That is, the computer running the POFA cannot be simultaneously running the operational program. The POFA consists of four separate tests that are discussed in the following paragraphs.

THE FUNCTION AND FORMAT TEST.— The function and format test checks the ability of the MTU to respond to computer commands and to provide status and error condition information.

THE DUPLEX TEST.— The duplex test checks MTU response to duplex control commands.

THE TRANSPORT COMPATIBILITY TEST.— The transport compatibility test checks the compatibility between the MTTs.

THE EXTENDED OPERATION TEST.— The extended operation test checks the ability of the MTU and MTTs to operate for extended time periods.

Periodicity of the POFA tests is determined by the PMS MIPs. You'll find the operating procedures in the NAVSEA POFA manual.

Peripheral Equipment Functional Test

The peripheral equipment functional tests (PEFTs) run under the control of the operational program computer. They are a subset of the dynamic combat system test (DCST) and are designed to be run online with and as part of the operational program. You can use the PEFT tests to check MTU write and read compatibility and to perform a function and format test of the MTU without interrupting the operational program.

SUMMARY—MAGNETIC TAPE STORAGE

This chapter has introduced you to magnetic tape storage concepts and atypical magnetic tape unit. The following information highlights points you should have learned.

MAGNETIC TAPE— Magnetic tape is made of a ferrous oxide material glued to a thin plastic or metal strip. Magnetic tape comes in a variety of sizes and lengths such as open reels, cartridges, and cassettes.

MAGNETIC TAPE HANDLING— Magnetic tape handling includes the storage, handling, maintenance, and control of tapes. By following the proper procedures, you can prevent damage to your tapes and safeguard the information contained on the tapes.

DATE STORAGE ON MAGNETIC TAPE— Magnetic tape storage concepts introduced you to how data is written on and read from magnetic tape. It also introduced you to the different methods used to encode data on the tape. These are return-to-zero (RZ), non-return-to-zero (NRZ), non-return-to-zero indiscrete (NRZI), and phase encoding (PE). Phase encoding allows for the highest densities of data, while retum-to-zero is limited to very low densities.

MAGNETIC TAPE UNIT— The magnetic tape unit is the device for writing and reading magnetic tape. It has two major functional areas; the magnetic tape controller and one or more magnetic tape transports (MTTs).

MAGNETIC TAPE CONTROLLER— The magnetic tape controller receives and processes data and commands from the host computer and sends data and status to the host computer. It provides timing and control signals to the MTT for read, write, search, and rewind operations.

MAGNETIC TAPE UNIT OPERATIONS— Magnetic tape units can perform the following operations: read, write, search, space file, and rewind.

MAGNETIC TAPE TRANSPORTS— The magnetic tape transports contain the electromechanical circuitry and motors to control all tape movement, reading and writing data, and sensing tape position (BOT/EOT), and tape errors (vacuum column fault).

MAINTENANCE REQUIREMENTS— Maintenance requirements for a typical tape unit involve periodic alignments and running of performance and diagnostic tests to ensure proper operation and compatibility.